OLSR Algorithm Presentation

The algorithm that will change the world

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Outline of the Presentation

Agenda

The problem

Routing Problem in MANETs

The challenge is to create a routing protocol for mobile ad-hoc networks (MANETs) that adapts in real-time to their constantly changing network topologies, ensuring reliable communication with minimal overhead. Traditional static routing protocols are ineffective in this dynamic environment, which is where the OLSR algorithm comes into play, aiming to resolve these issues.

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Motivation/Importance

Essential Connectivity: OLSR addresses the critical need for stable communication in dynamic environments like disaster recovery, military operations, and remote connectivity.

Real-world Reflection: The protocol models our social dynamics, where each node supports and relies on the network, highlighting our interconnected nature.

Broad Applications: From emergency services to smart vehicles, OLSR's efficiency is crucial for the next generation of wireless communication.

Complex Balance: Crafting a protocol that is both adaptive and lightweight in a constantly shifting network topology is a complex yet vital task.

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Definition of the Problem

The routing problem in MANETs that OLSR aims to solve involves determining the most efficient paths for data transmission between mobile nodes in a network where links frequently and unpredictably appear and disappear as nodes move.

Terminology

- MANET: Mobile ad-hoc network with self-configuring, infrastructure-less mobile devices.
- MPR (Multipoint Relays): Selected nodes that reduce broadcast repetitions by relaying messages during routing.
- Hello Messages: Used for neighbor discovery, sent periodically by nodes to directly connected neighbors.
- TC (Topology Control) Messages: Broadcast by nodes through MPRs to disseminate link state information across the network.

Background

- **AODV [1]:** Reactive like DSR; uses routing tables, unlike OLSR's MPRs.
- **DSDV [2]:** Proactive with full-table broadcasts; OLSR reduces overhead with selective flooding.
- **TORA [3]:** Adapts quickly to changes with link reversal; OLSR maintains consistent network topology knowledge.

Comparison

AODV (Ad-hoc On-Demand Distance Vector)

- **Advantage:** Efficient in managing bandwidth and battery power in mobile devices.
- **Disadvantage:** High latency in route discovery.

DSDV (Destination-Sequenced Distance-Vector)

- **Advantage:** Predictable performance due to regular updates.
- **Disadvantage:** High overhead and slow reaction to topology changes.

TORA (Temporally Ordered Routing Algorithm)

- **Advantage:** Quickly adapts to network topology changes.
- **Disadvantage:** Can create loops if not managed properly.

OLSR (Optimized Link State Routing)

- **Advantage:** Efficient in networks where frequent route updates are not needed.
- **Disadvantage:** Overhead can be significant in large and highly dynamic networks.

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Contributions

- **Proactive Routing:** OLSR provides constant route availability, which is crucial for applications requiring immediate route access.
- **MultiPoint Relays (MPRs):** Reduces the overhead of message flooding by using selected nodes to forward control messages.
- **Optimized Routing Control:** The protocol minimizes control traffic through incremental topology updates rather than full-fledged table exchanges.
- **Topology Dissemination:** OLSR's efficient dissemination of topology information ensures all nodes maintain consistent network knowledge.
- **Scalability:** Designed to scale well in larger networks compared to many other MANET routing protocols.

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OLSR Algorithm Overview

The Optimized Link State Routing (OLSR) algorithm involves the following key procedures:

- **Topology Discovery:** Nodes periodically exchange ”hello” messages to detect neighbors and assess link status.
- **MPR Selection:** Each node selects a set of neighboring nodes as MultiPoint Relays (MPRs) based on the network topology to efficiently forward messages.
- **Routing Table Calculation:** Nodes use topology information, primarily through MPRs, to calculate the shortest paths to all other nodes in the network.
- **Control Message Flooding:** MPRs disseminate Topology Control (TC) messages across the network, reducing the number of transmissions required to share topology changes.
- **Route Maintenance:** Nodes continuously monitor link status and adapt the network routing tables accordingly, ensuring up-to-date path availability.

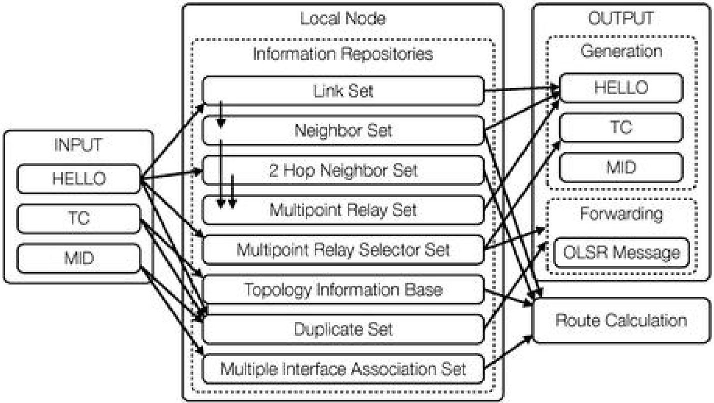

Figure: OLSR Algorithm Workflow [4]

Complexities

Time Complexity of MPR Selection

Worst Case: $O(N^2)$, where N is the number of nodes.
Practical Scenario: Often lower due to network sparsity and heuristic optimizations.

Computational Complexity

Routing Calculations: Utilizes Dijkstra's algorithm.
Worst Case: $O(N \log N)$.

Message Complexity

Worst Case: $O(N^2)$, assuming each node communicates with all others.
Reduced by MPRs: Actual complexity is significantly lower due to selective forwarding by MPRs.

OLSR Algorithm Pseudocode

```
Initialize: for each node do
    Set HelloInterval, TCInterval;
    Initialize Neighbor Table, Topology Table, Routing Table;
end
MainLoop: while network is operational do
    Every HelloInterval: BroadcastHelloMessage to neighbors;
    Every TCInterval: BroadcastTCMessage to MPRs;
    On receiving a message: Update tables and RecalculateRoutingTable();
    MaintainMPRSet based on Neighbor Table;
end
Procedure UpdateTables
    Message
if Hello message then
    update Neighbor Table;
else if TC message then
    update Topology Table;
end
Procedure RecalculateRoutingTable
    Compute shortest path using Topology Table;
Procedure MaintainMPRSet
    Select minimal set of neighbors covering all two-hop neighbors;
```

Step 1

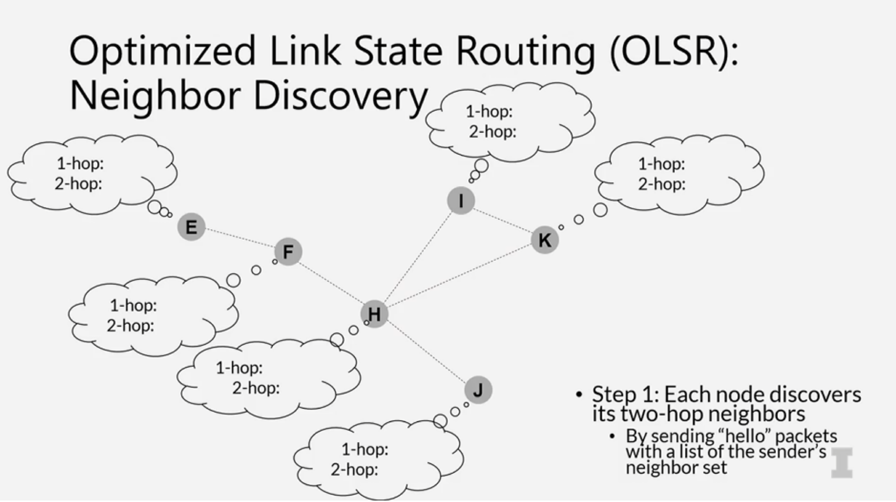

Figure: OLSR Algorithm [5]

Step 1

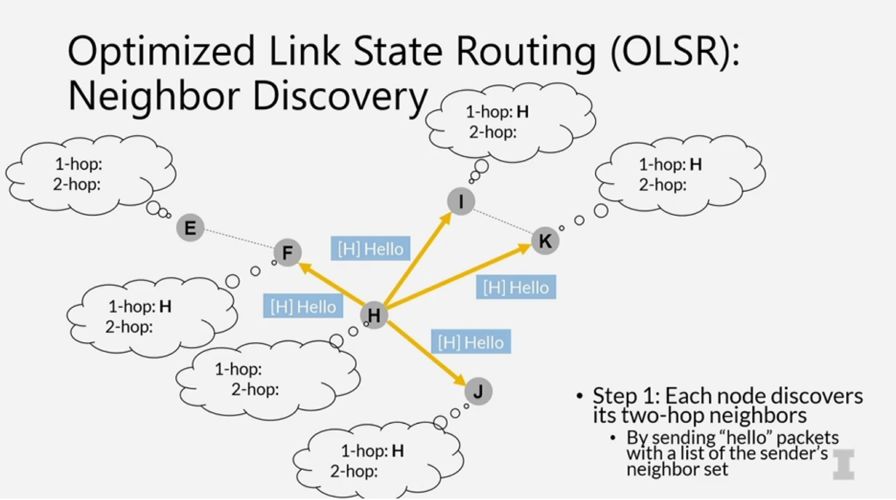

Figure: OLSR Algorithm Continued [5]

Step 1

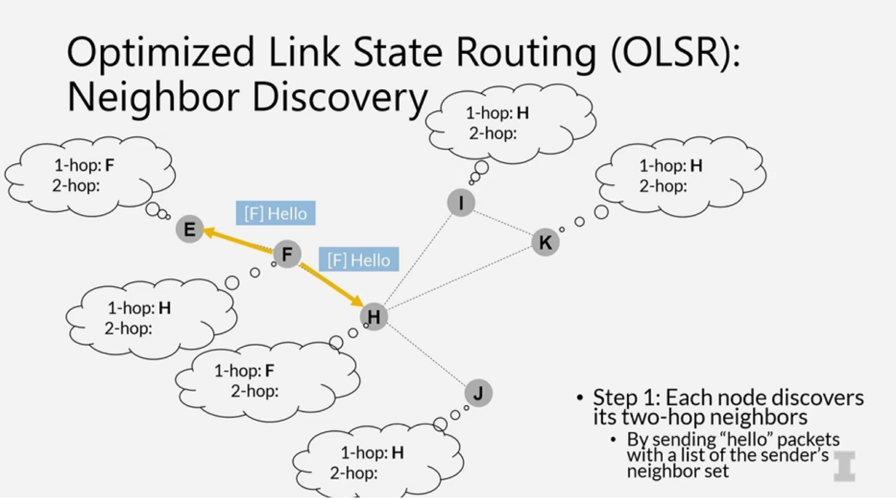

Figure: OLSR Algorithm Continued [5]

Step 1

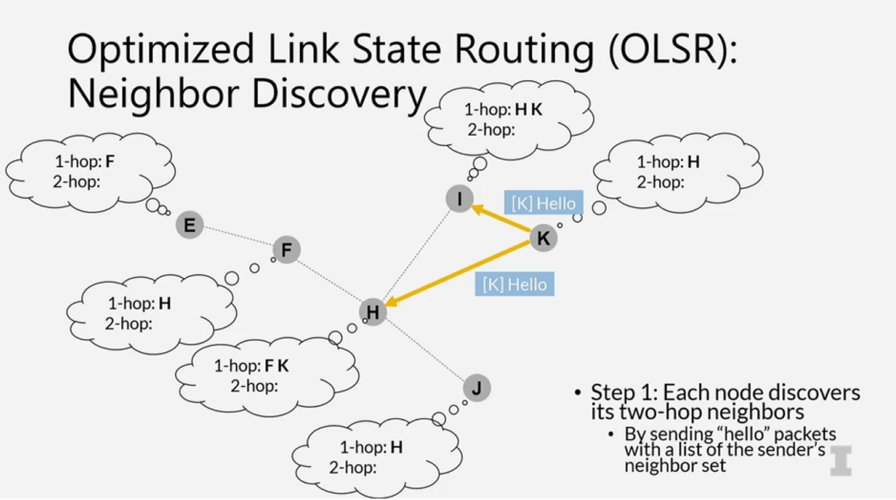

Figure: OLSR Algorithm Continued [5]

Step 1

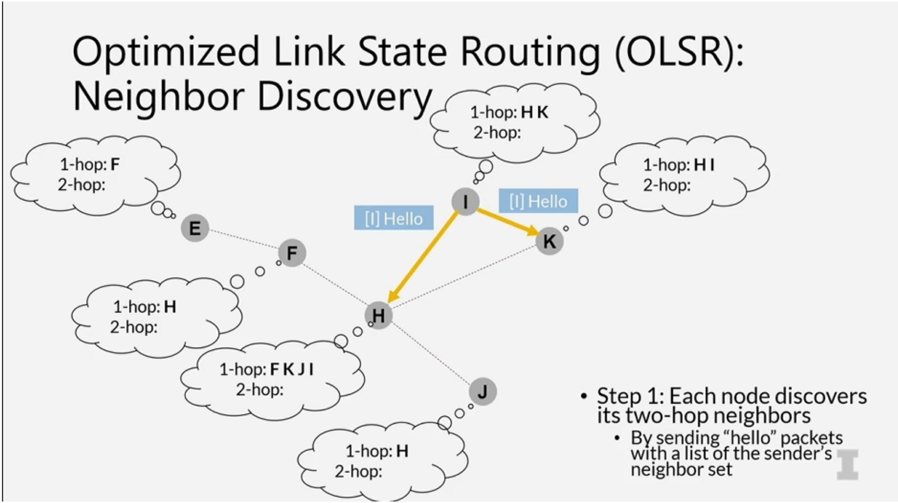

Figure: OLSR Algorithm Continued [5]

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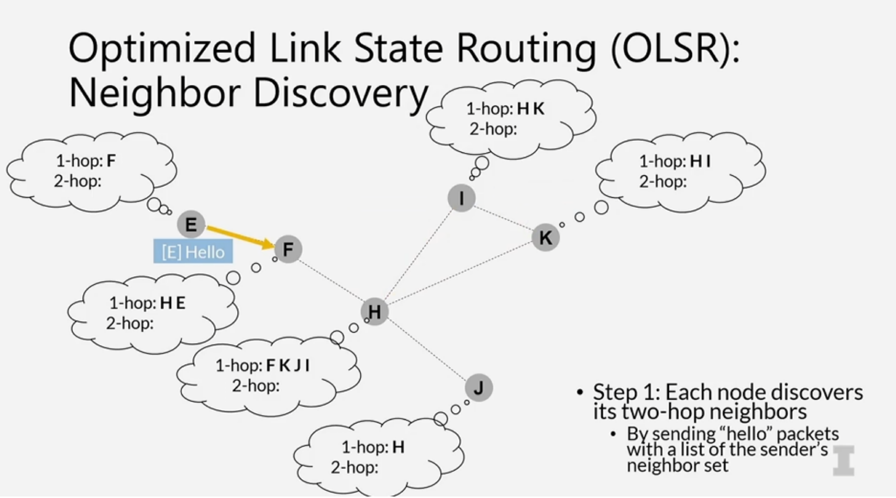

Figure: OLSR Algorithm Continued [5]

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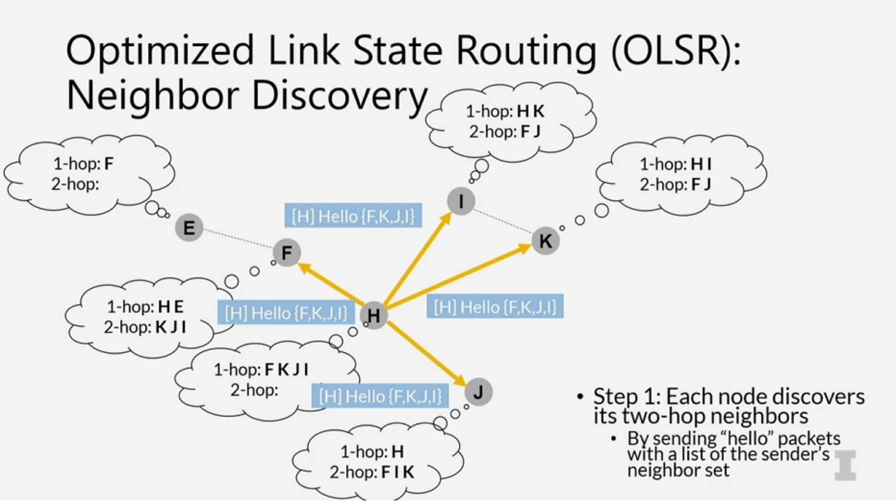

Figure: OLSR Algorithm Continued [5]

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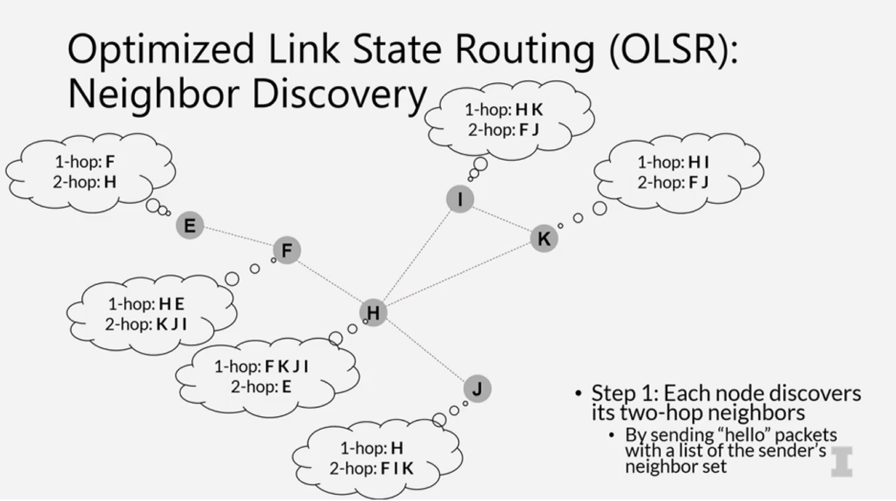

Figure: OLSR Algorithm Continued [5]

Step 2

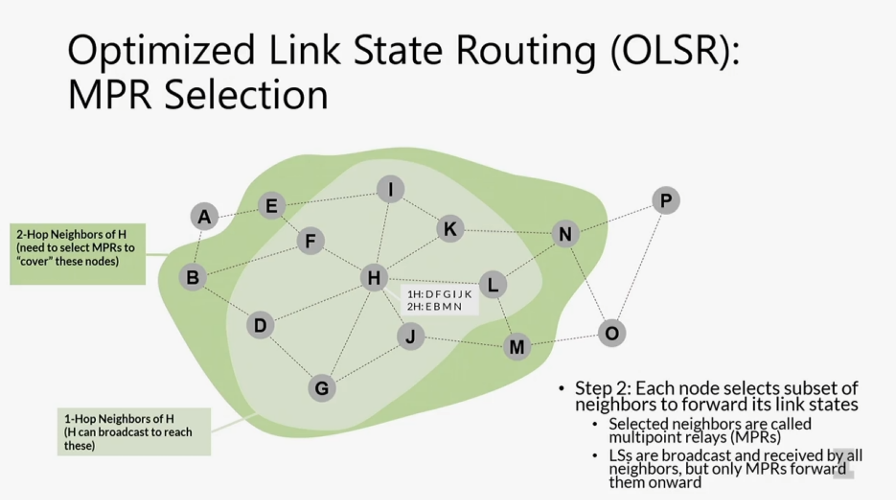

Figure: OLSR Algorithm Continued [5]

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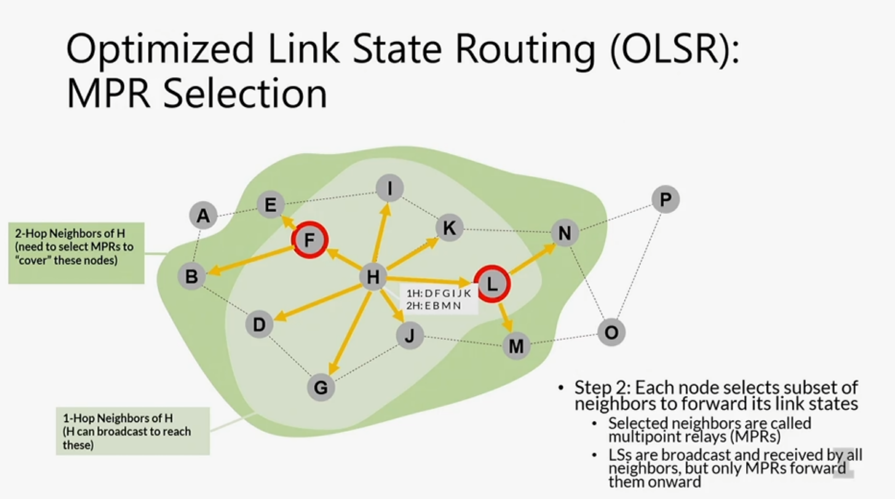

Figure: OLSR Algorithm Continued [5]

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Results outline

- (Qualitative) Convergence
- (Qualitative) Mobile adaptability
- (Quantitative) Comparison of Broadcasting Efficiency
- (Quantitative) Comparison of Addressed Message Delivery

Convergence

Below link leads to a gif that shows how the algorithm converges for 50 nodes. Blue nodes are the selected MPRs, green nodes are the nodes that fall within the coverage, and red nodes are the nodes that are uncovered.

Click Here to View the Convergence GIF

The timesteps of the animation are not actual time steps, but rather the flooding of the topology control message. By its nature, the OLSR algorithm converges after just one Topology Control flood.

Mobile Adaptability

The mobility plot in the OLSR protocol visualization demonstrates how the algorithm dynamically adapts to changes in network topology due to node mobility. It's been obtained by dynamically removing and adding edges to the topology.

Click Here to View the Mobility GIF

Broadcasting Efficiency

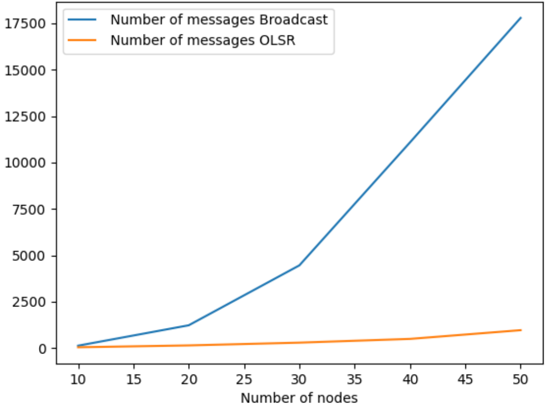

Figure: Broadcasting Efficiency Plot

Addressed Message Delivery

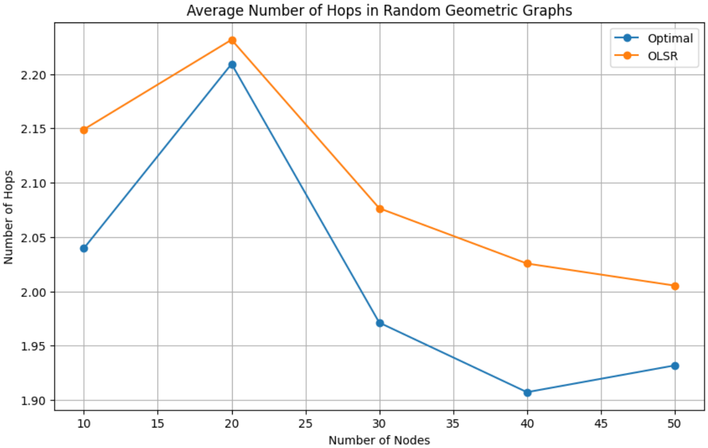

Figure: Broadcasting Efficiency Plot

Agenda

The Good

- Efficient and proactive routing protocol specifically designed for mobile ad hoc networks (MANETs).
- Utilizes Multi-Point Relays (MPRs) to significantly reduce the routing overhead, enhancing scalability.
- Capable of adapting rapidly to dynamic network topologies, ensuring effective routing amidst frequent changes.
- Near optimal performance with ultra fast convergence.

The Bad

- Stability issues: OLSR may face stability challenges due to incomplete knowledge of the entire network topology, occasionally resulting in sub-optimal routing paths.
- Performance degradation: In highly mobile scenarios, the periodic updating of routes may not keep pace with rapid topological changes, potentially degrading performance.
- Complexity in routing: The time complexity of MPR selection and the shortest path calculation can be high, potentially affecting performance as the network size increases.

The Ugly

- MPRs will be using a lot of energy.
- All topology information will be available at all nodes, which is a security risk.
- Different 'willingness' will be decreasing the optimality.

References

[1] C. Perkins and E. Royer, "Ad-hoc on-demand distance vector routing," in *Proceedings WMCSA'99. Second IEEE Workshop on Mobile Computing Systems and Applications*. IEEE, 1999. [Online]. Available: http://dx.doi.org/10.1109/MCSA.1999.749281

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[3] V. Park and M. Corson, "A highly adaptive distributed routing algorithm for mobile wireless networks," in *Proceedings of INFOCOM '97*, ser. INFOCOM-97. IEEE Comput. Soc. Press. [Online]. Available: http://dx.doi.org/10.1109/INFCOM.1997.631180

[4] Wikipedia, "Optimized link state routing protocol," 2022, accessed: 2022-02-22. [Online]. Available: https://en.wikipedia.org/wiki/Optimized_Link_State_Routing_Protocol

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Questions

THANK YOU

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